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(54) **Superconducting thin film having at least one isolated superconducting region formed of oxide superconductor material and method for manufacturing the same**

Supraleitende Dünnschicht mit mindestens einer isolierten Region, gebildet aus oxydisch supraleitendem Material und Verfahren zu ihrer Herstellung

Couche mince supraconductrice ayant au moins une région isolée supraconductrice formée en matériau supraconducteur d'oxyde et méthode pour sa fabrication

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- **IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY** vol. 1, no. 1, March 1991, NEW YORK, US pages 67-73. FORK D.K. ET AL Buffer Layers for High - Quality Epitaxial YBCO Films on Si
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EP 0 508 844 B1

Description

Background of the Invention

Field of the invention

The present invention relates to a superconducting thin film and a method for manufacturing the same, and more specifically to a superconducting thin film having at least an isolated superconducting region formed of oxide an material, and a method for manufacturing the same.

Description of related art

Elemental devices which utilize superconductivity operate at a higher speed with a lower power consumption so that they will have far better performance compared with semiconductor devices. The oxide superconductor material which has been recently advanced in study makes it possible to prepare superconducting devices which operate at relatively high temperature. Though a Josephson device is one of the most famous superconducting devices, logic circuits may be more easily assembled by using so called superconducting-base transistors or so called super-FETs (field effect transistor) which are three-terminal superconducting devices than by using Josephson devices which are two-terminal superconducting devices. Therefore, the superconducting-base transistor and the super-FET are more practical.

These superconducting devices have superconducting parts as superconducting electrodes, superconducting channels etc. These superconducting parts are usually formed of superconducting thin films.

To apply superconducting devices to various electronic equipments, these superconducting devices need to be incorporated within an IC (integrated circuit). There are many element devices on a substrate of an IC and each element device region is isolated. A superconducting thin film which has an isolated superconducting region is necessary to isolate a superconducting device region which is incorporated within IC. In case of a superconducting device formed of an oxide superconductor material which has been recently advanced in study, an oxide superconductor thin film which has an isolated superconducting region is necessary.

In the prior art, in order to isolate a superconducting region of an oxide superconductor thin film, a photoresist layer is deposited on a necessary portion of an oxide superconducting film and the deposited oxide superconductor thin film is etched back, until the exposing portion of the oxide superconductor thin film is removed at all and a surface of beneath layer exposes.

There is another conventional method in order to prepare an oxide superconductor thin film which has an isolated superconducting region, in which an oxide superconductor thin film is deposited on a substrate which

has a SiO_2 layer where an isolation region will be formed. Si included in the SiO_2 layer diffuses into a portion of the oxide superconductor thin film on the SiO_2 layer, so that the portion of the oxide superconductor thin film loses its superconductivity and changes into isolation region.

However, because of side etching etc., it is very difficult to conduct a fine processing by the etching process which uses a photoresist. In addition, a surface of an oxide superconductor thin film on which a photoresist layer is deposited will be contaminated by the photoresist. A side surface of an oxide superconductor thin film, which is exposed by etching is also contaminated by the etchant. Since oxide superconducting material is easily degraded by water and Cl ion, it is difficult to prepare a superconducting device of good property with an oxide superconductor material by a process in which an oxide superconductor thin film is processed by etching.

An oxide superconductor thin film which is deposited on a substrate which has a SiO_2 layer on a portion of its surface is not degraded. However, a step portion is produced on the surface of this oxide superconductor thin film at the edge of the SiO_2 layer. In order to prepare a superconducting device, other material layers must be stacked on the oxide superconductor thin film. Because of the step portion of the surface of the oxide superconductor thin film, a stacked structure including the oxide superconductor thin film and other material layers on it is not of good quality. Therefore, it is difficult to form a multilayer structure including the oxide superconductor thin film and to form a fine structure. Furthermore, the problems of low withstand voltage of the step portion of the isolation region of the oxide superconductor thin film occur.

It is known from FORK D.K. et al. (APPLIED PHYSICS LETTERS vol. 57, N° 23, 3 December 1990, New York, U.S., pages 2504-2506 : "Reaction patterning of $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ thin films" and IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY vol. 1, N° 1, March 1991, New York, U.S., pages 67-73 "Buffer Layers for High-Quality Epitaxial YBCO Films on Si") a patterned thin film comprising a superconducting region of a YBCO oxide superconductor and insulating regions of Si-YBCO, said thin film having a non-planar upper surface because of the insertion of an intermediate buffer layer of YSZ.

Furthermore, it is known from GURVITCH et al. (APPLIED PHYSICS LETTERS, 51 (13), 28 September 1987, pages 1027-1029 : "Preparation and substrate reactions of superconducting Y-Ba-Cu-O films") a two-stage method of sputtering metal films of YBa_2Cu_3 alloy followed by oxidation and annealing in O_2 atmosphere. This document shows that diffusant from a substrate affects the superconductivity of the superconductor thin film deposited on the substrate.

Summary of the Invention

Accordingly, it is an object of the present invention to provide an oxide superconductor thin film having a planar upper surface and at least one isolated superconducting region, which overcomes the above mentioned defects of the conventional ones.

Another object of the present invention is to provide a method for manufacturing an oxide superconductor thin film which overcomes the above mentioned defects of the conventional ones.

The above and other objects of the present invention are achieved in accordance with the present invention by a thin film disposed over a semiconductor substrate, and comprising at least one superconducting region formed of an oxide superconductor patterned by an isolation region formed of an oxide insulator including all the component atoms of the oxide superconductor and silicon as an impurity such that the superconductivity of the oxide superconductor is substantially lost by the impurity silicon, characterized in that the superconducting region is situated on a buffer layer not including silicon, the isolation region is situated on a SiO_2 layer, the buffer layer and the SiO_2 layer have the same thickness and the thin film has a planar upper surface.

According to another aspect of the present invention, there is provided a method for manufacturing a thin film over a semiconductor substrate, the thin film having at least one superconducting region formed of an oxide superconductor patterned by an isolation region formed of an oxide insulator including all the component atoms of the oxide superconductor and silicon as an impurity such that the superconductivity of the oxide superconductor is substantially lost by the impurity silicon, characterized in that the method comprising the steps of forming a SiO_2 layer on a portion of the semiconductor substrate, over which the isolation region is arranged and a buffer layer on a portion of the semiconductor substrate, over which the superconducting region is arranged in such a manner that both upper surfaces of the semiconductor oxide layer and of the buffer layer are at a same level, and growing an oxide superconductor thin film on the SiO_2 layer and the buffer layer so that silicon diffuses into the portion of the oxide superconductor thin film on the SiO_2 layer so as to form the isolation region, and so that an upper surface of the thin film becomes planar.

In a preferred embodiment, the oxide superconductor is formed of a high- T_c (high critical temperature) oxide superconductor, particularly, formed of a high- T_c copper-oxide type compound oxide superconductor for example a Y-Ba-Cu-O type compound oxide superconductor material, a Bi-Sr-Ca-Cu-O type compound oxide superconductor material, and a Tl-Ba-Ca-Cu-O type compound oxide superconductor material.

In addition, the substrate can be formed of a semiconductor such as silicon, germanium, GaAs, InP, InGaAs, InGaAsP, etc. The semiconductor oxide layer is

preferably formed of oxide of the semiconductor which constitutes the semiconductor substrate. In other words, the semiconductor oxide layer is formed by oxidizing a portion of the surface of the semiconductor substrate.

Since the superconducting thin film manufactured in accordance with the present invention has a planar upper surface, it is easy to form a multilayer structure and also a fine structure. This flat surface of the superconducting thin film also improves the withstand voltage of the isolation region.

In a preferred embodiment, the buffer layer on the semiconductor substrate can be formed of a double-layer coating formed of a MgAl_2O_4 layer and a BaTiO_3 layer if silicon is used as a substrate. This MgAl_2O_4 layer is formed by a CVD (chemical vapor deposition) and the BaTiO_3 layer is formed by a sequential sputtering process.

In the process of in accordance with the present invention, atoms included in the semiconductor oxide diffuse into a portion of an oxide superconductor thin film growing on the semiconductor oxide layer, and the portion of the oxide superconductor loses its superconductivity and is converted into the isolation region formed of an oxide insulator including component atoms of the oxide superconductor. On the other hand, a crystalline oxide superconductor thin film grows on the buffer layer, which constitutes the superconducting region. Since there is no etching process by which the oxide superconductor thin film is directly processed in the method in accordance with the present invention, the oxide superconductor thin film is not contaminated and degraded.

The above and other objects, features and advantages of the present invention will be apparent from the following description of preferred embodiments of the invention with reference to the accompanying drawings.

Brief Description of the Drawings

Figures 1 is a diagrammatic plane view of a preferred embodiment of the the superconducting thin film in accordance with the present invention; Figures 2 is a diagrammatic plane view of another preferred embodiment of the superconducting thin film in accordance with the present invention; Figures 3A to 3G are diagrammatic sectional views for illustrating a first embodiment of the process in accordance with the present invention for manufacturing the superconducting thin film; Figures 4A to 4G are diagrammatic sectional views for illustrating a second embodiment of the process in accordance with the present invention for manufacturing the superconducting thin film.

Description of the Preferred embodiments

Figure 1 shows a diagrammatic plane view of one preferred embodiment of the superconducting thin film

in accordance with the present invention. In Figure 1, a superconducting thin film 10 includes a superconducting region 1 formed of a $Y_1Ba_2Cu_3O_{7-\delta}$ oxide superconductor material and arranged on the silicon substrate 3 and a insulation region 11 formed of a $Y_1Ba_2Cu_3O_{7-\epsilon}$ oxide insulator which includes silicon and surrounding the superconducting region 1. The superconducting thin film 10 has a planar upper surface, namely the upper surface of the superconducting region 1 and the upper surface of the isolation region 11 is at the same level.

$Y_1Ba_2Cu_3O_{7-\epsilon}$ oxide insulator which constitutes the insulating region 11 includes all the component atoms of a $Y_1Ba_2Cu_3O_{7-\delta}$ oxide superconductor material, such as Y, Ba, Cu and O, and silicon as an impurity. Owing to the impurity silicon, the $Y_1Ba_2Cu_3O_{7-\epsilon}$ oxide does not have superconductivity, though its lattice structure is almost same as that of a $Y_1Ba_2Cu_3O_{7-\delta}$ oxide superconductor.

Figure 2 shows another preferred embodiment of the superconducting thin film in accordance with the present invention, in which the superconducting thin film 10 has multiple superconducting regions 1 and isolation regions 11.

Referring to Figures 3A to 3G, the process in accordance with the present invention for manufacturing the superconducting thin film will be described.

As shown in Figure 3A, a SiO_2 layer 4 having a thickness of 450 nanometers is formed on a silicon substrate 3 by a CVD process. This substrate 3 is not limited to a silicon substrate but to any semiconductor substrate, for example germanium, GaAs, InP, InGaAs, InGaAsP, etc.

As shown in Figure 3B, a photoresist layer 5 is deposited on the SiO_2 layer 4. Then, the photoresist layer 5 and also the SiO_2 layer 4 are patterned so that a portion of the silicon substrate 3 is exposed, on which the superconducting region will be formed, and the SiO_2 layer 4 remains the portion of the silicon substrate 3, on which the isolation region will be formed, as shown in Figure 3D.

Thereafter, as shown in Figure 3E, a buffer layer is deposited on the exposed portion of silicon substrate 3. In the case of the silicon substrate, the buffer layer is preferably formed of $MgAl_2O_4$ film 21 by a CVD (chemical vapor deposition) and of $BaTiO_3$ film 22 by a sequential sputtering process. The $MgAl_2O_4$ film 21 has a thickness of 350 nanometers and the $BaTiO_3$ film 22 has a thickness of 100 nanometers. This buffer layer formed of the double-layer has almost same thickness as that of the SiO_2 layer 4.

Then, as shown in Figure 3F, the photoresist layer 5 is removed so that SiO_2 layer 4 is exposed. As shown in Figure 3G, a $Y_1Ba_2Cu_3O_{7-\delta}$ oxide superconductor thin film 10 is deposited on the SiO_2 layer 4 and the $BaTiO_3$ film 22, by for example an off-axis sputtering, a reactive evaporation, an MBE (molecular beam epitaxy), a CVD, etc. A condition of forming the $Y_1Ba_2Cu_3O_{7-\delta}$ oxide superconductor thin film 10 by off-axis sputtering is as follows:

Sputtering Gas	Ar: 90%
	O ₂ : 10%
Pressure	10 Pa
Temperature of the substrate	700 - 750 °C
Thickness	200 nanometers

The oxide superconductor thin film is preferably formed of a high- T_c (high critical temperature) oxide superconductor material, particularly a high- T_c copper-oxide type compound oxide superconductor material, for example, a Bi-Sr-Ca-Cu-O type compound oxide superconductor material, or a Tl-Ba-Ca-Cu-O type compound oxide superconductor material other than a Y-Ba-Cu-O type compound oxide superconductor material.

Silicon included SiO_2 layer 4 diffuses into the portion of the oxide superconductor thin film 10 which is deposited on the SiO_2 layer 4 so that the $Y_1Ba_2Cu_3O_{7-\delta}$ oxide superconductor of the portion is converted into a $Y_1Ba_2Cu_3O_{7-\epsilon}$ oxide insulator and the isolation region 11 is formed.

The portion of the oxide superconductor thin film 10 which is deposited on the $BaTiO_3$ film 22 is formed of the c-axis orientated crystalline $Y_1Ba_2Cu_3O_{7-\delta}$ oxide superconductor. With this, the superconducting thin film in accordance with the present invention is completed.

As explained above, if the superconducting thin film is manufactured in accordance with the first embodiment of the method of the present invention, no etching process is used for processing of the oxide superconductor thin film. Therefore, the oxide superconductor thin film is not contaminated and degraded. Since the flatness of the upper surface of the superconducting thin film can be improved, it become easy to form other layers on the upper surface of the superconducting thin film in a later process. Further more, since the isolation region is formed of an oxide which is made of the same composition and has same crystal structure as those of the oxide superconductor constituting the superconducting region, the superconducting thin film is superior in mechanical stability. Accordingly, it is easy to manufacture the superconducting thin film with good repeatability, and the manufactured superconducting thin film has a stable performance.

Referring to Figures 4A to 4G a second embodiment of the process for manufacturing the superconducting thin film will be described.

As shown in Figure 4A, there is prepared a silicon substrate 3, similar to the substrate 3 shown in Figure 3A.

As shown in Figure 4B, a buffer layer is deposited on the exposed portion of silicon substrate 3. In the case of the silicon substrate, the buffer layer is preferably formed of $MgAl_2O_4$ film 21 by a CVD (chemical vapor deposition) and of $BaTiO_3$ film 22 by a sequential sputtering process. The $MgAl_2O_4$ film 21 has a thickness of

350 nanometers and the BaTiO₃ film 22 has a thickness of 75 nanometers.

Then, as shown in Figure 4C, a photoresist layer 5 is deposited on a portion of the BaTiO₃ film 22, on which the superconducting region will be formed. Thereafter, as shown in Figure 4D, a portion of the BaTiO₃ film 22 and the MgAl₂O₄ film 21 which is not coated with photoresist 5 is removed by a reactive ion etching process or an ion milling using Ar-ions, so that the portion of silicon substrate 3 is exposed. It is not a problem that the portion of the silicon substrate is etched slightly.

Then, as shown in Figure 4E, the portion of silicon substrate 3 exposed is oxidized by the water vapor so that a SiO₂ layer 4 which has an upper surface level with that of the BaTiO₃ film 22 is formed. If necessary, the silicon substrate 3 is etched before the oxidation, so that no step is generated between the upper surface of the SiO₂ layer 4 and that of the BaTiO₃ film 22.

After that, as shown in Figure 4F, the photoresist 5 is removed so that the BaTiO₃ film 22 is exposed. The exposed surface of the BaTiO₃ film 22 is cleaned by pre-sputtering. Then, as shown in Figure 4G, a Y₁Ba₂Cu₃O_{7- δ} oxide superconductor thin film 10 is deposited on the SiO₂ layer 4 and the BaTiO₃ film 22, by for example an off-axis sputtering, a reactive evaporation, an MBE (molecular beam epitaxy), a CVD, etc. A condition of forming the Y₁Ba₂Cu₃O_{7- δ} oxide superconductor thin film 10 by off-axis sputtering is as follows:

Sputtering Gas	Ar: 90%
	O ₂ : 10%
Pressure	10 Pa
Temperature of the substrate	700 - 750 °C
Thickness	200 nanometers

The oxide superconductor thin film is preferably formed of a high-T_c (high critical temperature) oxide superconductor material, particularly a high-T_c copper-oxide type compound oxide superconductor material, for example, a Bi-Sr-Ca-Cu-O type compound oxide superconductor material, or a Ti-Ba-Ca-Cu-O type compound oxide superconductor material other than a Y-Ba-Cu-O type compound oxide superconductor material.

Silicon included in SiO₂ layer 4 diffuses into the portion of the oxide superconductor thin film 10 which is deposited on the SiO₂ layer 4 so that the Y₁Ba₂Cu₃O_{7- δ} oxide superconductor of the portion is converted into a Y₁Ba₂Cu₃O_{7- ϵ} oxide insulator and the isolation region 11 is formed.

The portion of the oxide superconductor thin film 10 which is deposited on the BaTiO₃ film 22 is formed of the c-axis orientated crystalline Y₁Ba₂Cu₃O_{7- δ} oxide superconductor. With this, the superconducting thin film in accordance with the present invention is completed.

As explained above, if the superconducting thin film is manufactured in accordance with the second embod-

iment of the method of the present invention, no etching process is used for processing of the oxide superconductor thin film. Therefore, the oxide superconductor thin film is not contaminated and degraded. Since the flatness of the upper surface of the superconducting thin film can be improved, it becomes easy to form other layers on the upper surface of the superconducting thin film in a later process. Furthermore, since the isolation region is formed of an oxide which is made of the same composition and has the same crystal structure as those of the oxide superconductor constituting the superconducting region, the superconducting thin film is superior in mechanical stability. Accordingly, it is easy to manufacture the superconducting thin film with good repeatability, and the manufactured superconducting thin film has a stable performance.

The invention has thus been shown and described with reference to the specific embodiments. However, it should be noted that the present invention is in no way limited to the details of the illustrated structures but converts and modifications may be made within the scope of the appended claims.

Claims

1. A thin film disposed over a semiconductor substrate, and comprising at least one superconducting region formed of an oxide superconductor patterned by an isolation region formed of an oxide insulator including all the component atoms of the oxide superconductor and silicon as an impurity such that the superconductivity of the oxide superconductor is substantially lost by the impurity silicon, **characterized in that** the superconducting region is situated on a buffer layer not including silicon, the isolation region is situated on a SiO₂ layer, the buffer layer and the SiO₂ layer have the same thickness and the thin film has a planar upper surface.
2. A thin film claimed in Claim 1, **characterized in that** the thin film comprises plural patterned superconducting regions and plural isolation regions.
3. A thin film claimed in Claim 1 or 2, **characterized in that** the buffer layer comprises a lower MgAl₂O₄ layer and an upper BaTiO₃ layer.
4. A thin film claimed in any one of Claims 1 to 3, **characterized in that** the superconducting region is formed of a high-T_c (high critical temperature) oxide superconductor.
5. A thin film claimed in Claim 4, **characterized in that** the superconducting region is formed of a high-T_c copper-oxide type compound oxide superconductor.

6. A thin film claimed in Claim 5, **characterized in that** the superconducting region is formed of an oxide superconductor material selected from the group consisting of a Y-Ba-Cu-O type compound oxide superconductor material, a Bi-Sr-Ca-Cu-O type compound oxide superconductor material, and a Tl-Ba-Ca-Cu-O type compound oxide superconductor material.

7. A thin film claimed in anyone of Claims 1 to 6 **characterized in that**, the substrate is formed of a silicon substrate, germanium substrate, GaAs substrate, InP substrate, InGaAs substrate or InGaAsP substrate.

8. A method for manufacturing a thin film over a semiconductor substrate, the thin film having at least one superconducting region formed of an oxide superconductor patterned by an isolation region formed of an oxide insulator including all the component atoms of the oxide superconductor and silicon as an impurity such that the superconductivity of the oxide superconductor is substantially lost by the impurity silicon, **characterized in that** the method comprising the steps of forming a SiO₂ layer on a portion of the semiconductor substrate, over which the isolation region is arranged and a buffer layer on a portion the semiconductor substrate, over which the superconducting region is arranged in such a manner that the both upper surfaces of the semiconductor oxide layer and of the buffer layer are at a same level, and growing an oxide superconductor thin film on the SiO₂ layer and the buffer layer so that silicon diffuses into the portion of the oxide superconductor thin film on the SiO₂ layer so as to form the isolation region, and so that an upper surface of the thin film becomes planar.

9. A method claimed in Claim 8, **characterized in that** the semiconductor substrate is a silicon substrate and the buffer layer comprises a double-layer formed of a MgAl₂O₄ layer and a BaTiO₃ layer.

10. A method claimed in Claim 9, **characterized in that** the MgAl₂O₄ layer is formed by a CVD (chemical vapor deposition) and the BaTiO₃ layer is formed by a sequential sputtering process.

11. A method claimed in anyone of Claims 8 to 10, **characterized in that** the oxide superconductor thin film is formed by an off-axis sputtering, a reactive evaporation, an MBE or a CVD.

12. A method claimed in anyone of Claims 8 to 11, **characterized in that** the SiO₂ layer is formed by a CVD.

13. A method claimed in anyone of Claims 8 to 11, **characterized in that** the SiO₂ layer is formed by oxidation of water vapor.

dation of water vapor.

Patentansprüche

1. Dünnschicht, die über einem Halbleitersubstrat angeordnet ist und wenigstens eine supraleitenden Bereich aufweist, der aus einem oxidischen Supraleiter gebildet ist, der durch einen isolierenden Bereich strukturiert ist, der aus einem oxidischen Isolator gebildet ist und sämtliche Bestandteilatome des oxidischen Supraleiters sowie Silicium als Verunreinigung derart aufweist, daß die Supraleitfähigkeit des oxidischen Supraleiters durch das Verunreinigungssilicium im wesentlichen verlorengeht, dadurch gekennzeichnet, daß der supraleitende Bereich auf einer kein Silicium enthaltenden Pufferschicht angeordnet ist, der isolierende Bereich auf einer SiO₂-Schicht angeordnet ist, die Pufferschicht und die SiO₂-Schicht dieselbe Dicke haben und die Dünnschicht eine ebene bzw. planare Oberseite hat.
2. Dünnschicht nach Anspruch 1, dadurch gekennzeichnet, daß die Dünnschicht mehrere strukturierte supraleitende Bereiche und mehrere isolierende Bereiche hat.
3. Dünnschicht nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Pufferschicht eine untere MgAl₂O₄-Schicht und eine obere BaTiO₃-Schicht aufweist.
4. Dünnschicht nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß der supraleitende Bereich aus einem oxidischen Supraleiter mit hoher T_c (hohe kritische Temperatur) gebildet ist.
5. Dünnschicht nach Anspruch 4, dadurch gekennzeichnet, daß der supraleitende Bereich aus einem supraleitenden Verbundoxid vom Kupfer-Oxid-Typ mit hoher T_c gebildet ist.
6. Dünnschicht nach Anspruch 5, dadurch gekennzeichnet, daß der supraleitende Bereich aus einem oxidischen supraleitenden Material gebildet ist, das aus der Gruppe ausgewählt ist, die aus einem supraleitenden Verbundoxid vom Y-Ba-Cu-O-Typ, einem supraleitenden Verbundoxid vom Bi-Sr-Ca-Cu-O-Typ und einem supraleitenden Verbundoxid vom Tl-Ba-Ca-Cu-O-Typ besteht.
7. Dünnschicht nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß das Substrat aus einem Siliciumsubstrat, Germaniumsubstrat, GaAs-Substrat, InP-Substrat, InGaAs-Substrat oder InGaAsP-Substrat gebildet ist.

8. Verfahren zur Herstellung einer Dünnschicht über einem Halbleitersubstrat, wobei die Dünnschicht wenigstens einen supraleitenden Bereich aufweist, der aus einem oxidischen Supraleiter gebildet ist, der durch einen isolierenden Bereich strukturiert ist, der aus einem oxidischen Isolator einschließlich sämtlicher Bestandteilatome des oxidischen Supraleiters und Silicium als Verunreinigung derart gebildet ist, daß die Supraleitfähigkeit des oxidischen Supraleiters durch das Verunreinigungssilicium im wesentlichen verlorengeht, dadurch gekennzeichnet, daß das Verfahren die Schritte aufweist: Bilden einer SiO_2 -Schicht auf einem Abschnitt des Halbleitersubstrats, über welchem der isolierende Bereich angeordnet ist, und einer Pufferschicht auf einem Abschnitt des Halbleitersubstrats, über welchem der supraleitende Bereich derart angeordnet ist, daß die beiden Oberseiten der oxidischen Halbleiterschicht und der Pufferschicht miteinander fluchten, und Aufwachsen einer oxidischen supraleitenden Dünnschicht auf der SiO_2 -Schicht und der Pufferschicht derart, daß Silicium in den Abschnitt der oxidischen supraleitenden Dünnschicht auf der SiO_2 -Schicht derart diffundiert, daß der Isolationsbereich gebildet wird, so daß die Oberseite der Dünnschicht eben bzw. planar wird.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß das Halbleitersubstrat ein Siliciumsubstrat ist und die Pufferschicht eine Doppelschicht aufweist, die aus einer MgAl_2O_4 -Schicht und einer BaTiO_3 -Schicht gebildet ist.

10. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß die MgAl_2O_4 -Schicht durch CVD (chemische Dampfabcheidung) gebildet wird und die BaTiO_3 -Schicht durch einen sequentiellen Sputterprozeß gebildet wird.

11. Verfahren nach einem der Ansprüche 8 bis 10, dadurch gekennzeichnet, daß die oxidische supraleitende Dünnschicht durch Außer-Achsensputtern, reaktives Verdampfen, MBE oder CVD gebildet wird.

12. Verfahren nach einem der Ansprüche 8 bis 11, dadurch gekennzeichnet, daß die SiO_2 -Schicht durch CVD gebildet wird.

13. Verfahren nach einem der Ansprüche 8 bis 11, dadurch gekennzeichnet, daß die SiO_2 -Schicht durch Oxidation von Wasserdampf gebildet wird.

Revendications

1. Couche mince disposée sur un substrat semi-con-

ducteur et comprenant au moins une région supraconductrice, formée d'un supraconducteur de type oxyde, configurée par une région d'isolement formée d'un isolant de type oxyde comprenant tous les atomes constitutifs du supraconducteur de type oxyde, et du silicium en tant qu'impureté, si bien que la supraconductivité du supraconducteur de type oxyde est essentiellement supprimée par l'impureté constituée du silicium, caractérisée en ce que la région supraconductrice est située sur une couche tampon ne contenant pas de silicium, la région d'isolement est située sur une couche de SiO_2 , la couche tampon et la couche de SiO_2 ont la même épaisseur et la couche mince a une surface supérieure plane.

2. Couche mince selon la revendication 1, caractérisée en ce que la couche mince comprend plusieurs régions supraconductrices configurées et plusieurs régions d'isolement.

3. Couche mince selon la revendication 1 ou 2, caractérisée en ce que la couche tampon comprend une couche inférieure de MgAl_2O_4 et une couche supérieure de BaTiO_3 .

4. Couche mince selon l'une quelconque des revendications 1 à 3, caractérisée en ce que la région supraconductrice est formée d'un supraconducteur de type oxyde ayant une T_c élevée (température critique élevée).

5. Couche mince selon la revendication 4, caractérisée en ce que la région supraconductrice est formée d'un supraconducteur à base d'oxyde mixte de type oxyde de cuivre ayant une T_c élevée.

6. Couche mince selon la revendication 5, caractérisée en ce que la région supraconductrice est formée d'une matière supraconductrice de type oxyde choisie parmi une matière supraconductrice à base d'oxyde mixte de type Y-Ba-Cu-O, une matière supraconductrice à base d'oxyde mixte de type Bi-Sr-Ca-Cu-O et une matière supraconductrice à base d'oxyde mixte de type Tl-Ba-Ca-Cu-O.

7. Couche mince selon l'une quelconque des revendications 1 à 6, caractérisée en ce que le substrat est formé d'un substrat de silicium, d'un substrat de germanium, d'un substrat de GaAs, d'un substrat d'InP, d'un substrat d'InGaAs ou d'un substrat d'InGaAsP.

8. Procédé pour la fabrication d'une couche mince sur un substrat semiconducteur, la couche mince ayant au moins une région supraconductrice, formée d'un supraconducteur de type oxyde, configurée par une région d'isolement formée d'un isolant de type oxy-

de comprenant tous les atomes constitutifs du supraconducteur de type oxyde, et du silicium en tant qu'impureté, si bien que la supraconductivité du supraconducteur de type oxyde est essentiellement supprimée par l'impureté constituée du silicium, ce procédé étant caractérisé en ce qu'il comprend les étapes de formation d'une couche de SiO_2 sur une portion du substrat semiconducteur sur laquelle la région d'isolement est disposée et d'une couche tampon sur une portion du substrat semiconducteur sur laquelle la région supraconductrice est disposée, de telle sorte que les deux surfaces supérieures de la couche de semi-conducteur de type oxyde et de la couche tampon soient au même niveau, et de croissance d'une couche mince de supraconducteur de type oxyde sur la couche de SiO_2 et la couche tampon, afin que le silicium diffuse dans la portion de la couche mince de supraconducteur de type oxyde sur la couche de SiO_2 , de façon à former la région d'isolement et de façon à ce que la surface supérieure de la couche mince devienne plane.

9. Procédé selon la revendication 8, caractérisé en ce que le substrat semiconducteur est un substrat de silicium et la couche tampon comprend une couche double formée d'une couche de MgAl_2O_4 et d'une couche de BaTiO_3 .
10. Procédé selon la revendication 9, caractérisé en ce que la couche de MgAl_2O_4 est formée par DCV (dépôt chimique en phase vapeur) et la couche de BaTiO_3 est formée par une opération ultérieure de pulvérisation cathodique.
11. Procédé selon l'une quelconque des revendications 8 à 10, caractérisé en ce que la couche mince de supraconducteur de type oxyde est formée par pulvérisation cathodique désaxée, évaporation réactive, épitaxie par faisceaux moléculaires ou DCV.
12. Procédé selon l'une quelconque des revendications 8 à 11, caractérisé en ce que la couche de SiO_2 est formée par DCV.
13. Procédé selon l'une quelconque des revendications 8 à 11, caractérisé en ce que la couche de SiO_2 est formée par oxydation par la vapeur d'eau.

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FIGURE 1

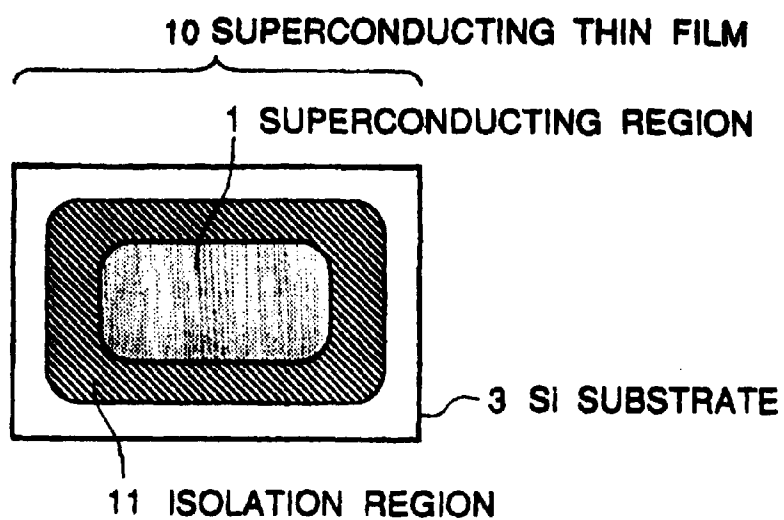


FIGURE 2

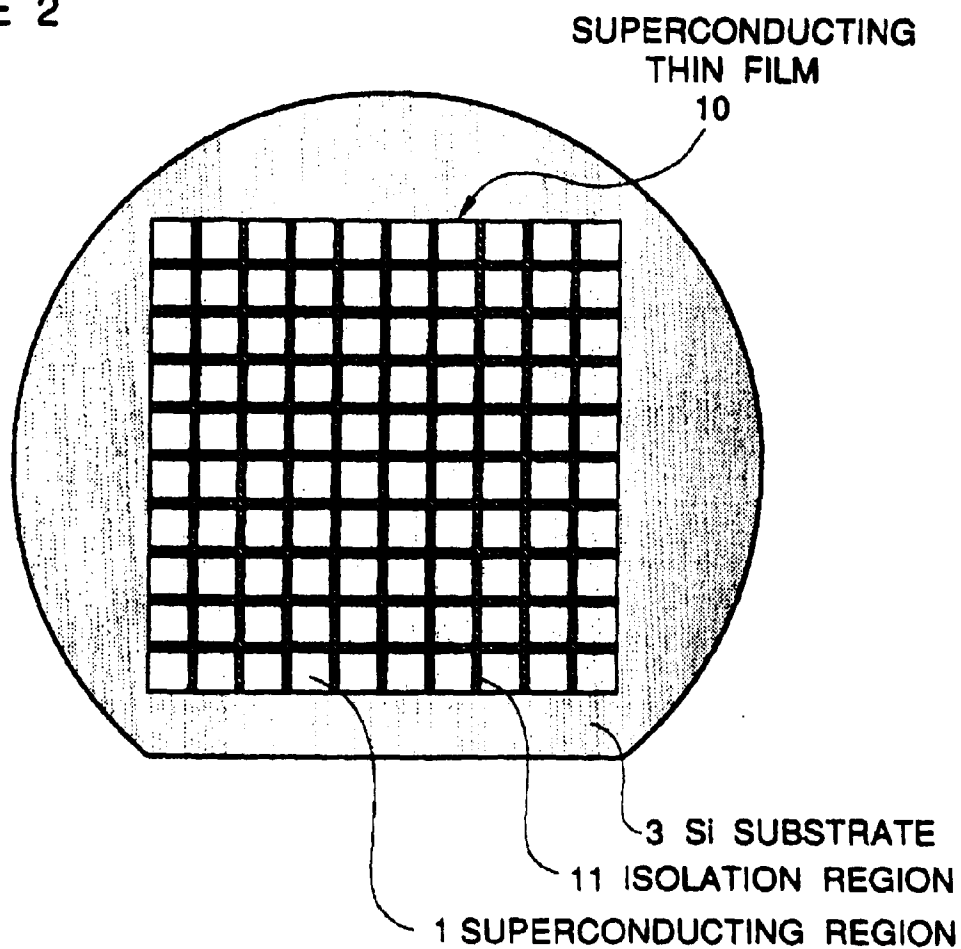


FIGURE 3A



FIGURE 3B

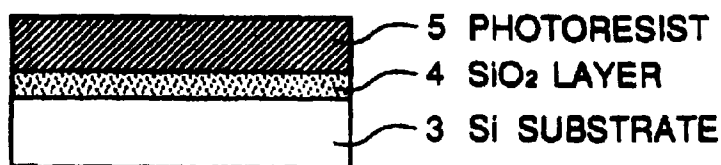


FIGURE 3C

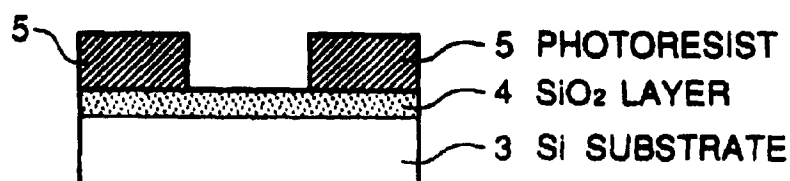


FIGURE 3D

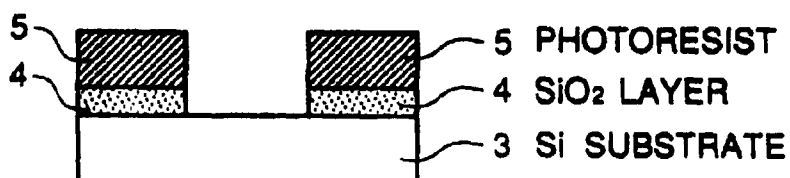


FIGURE 3E

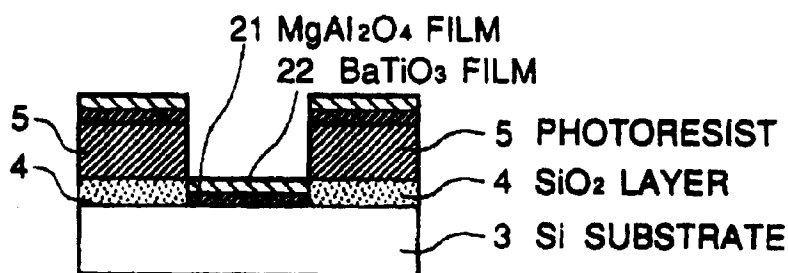


FIGURE 3F

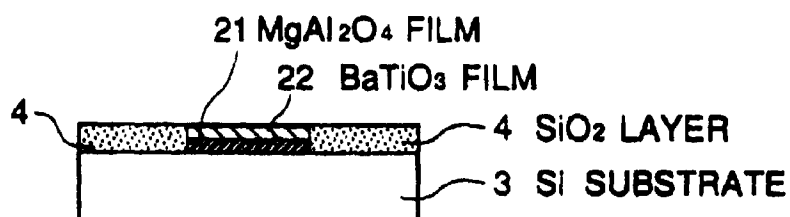


FIGURE 3G

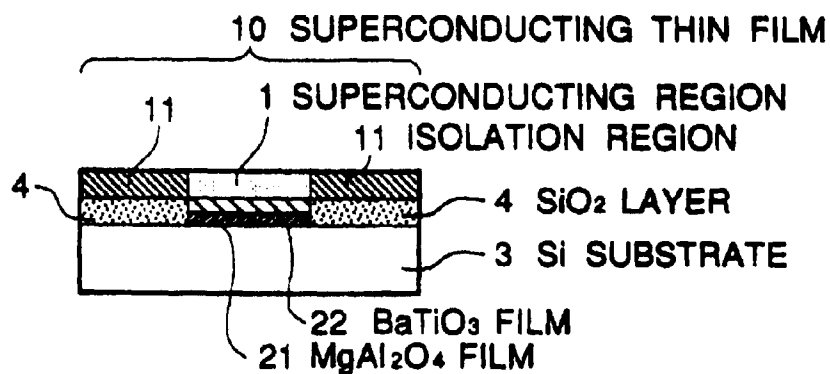


FIGURE 4A



FIGURE 4B

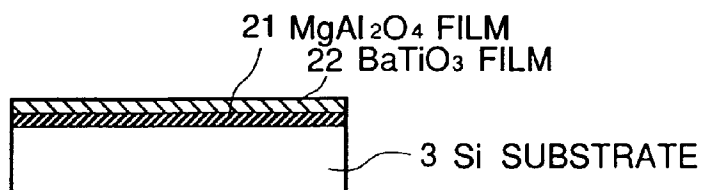


FIGURE 4C

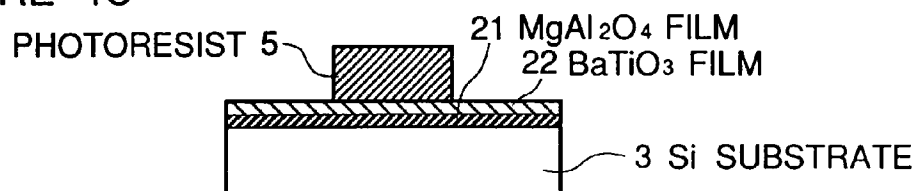


FIGURE 4D

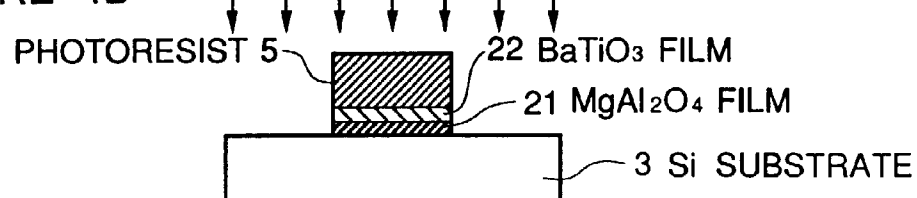


FIGURE 4E

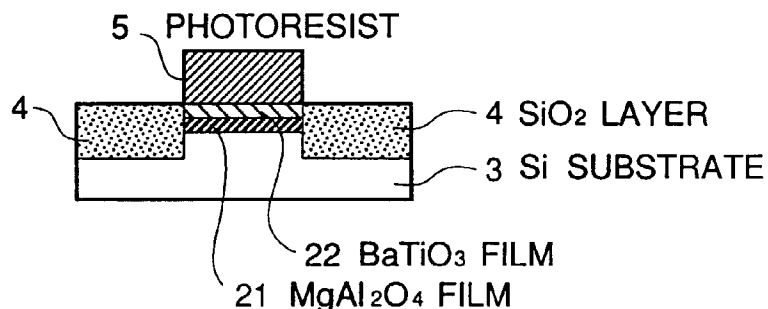


FIGURE 4F

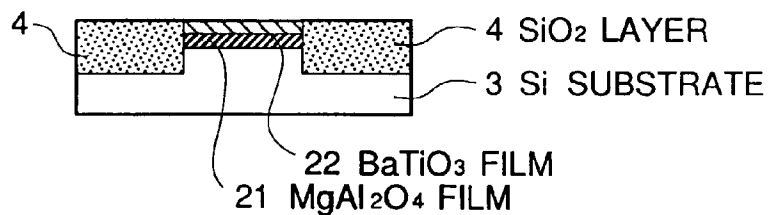


FIGURE 4G

